



## Investigations on the Effect of Moisture Content and Variety Factors on Some Physical Properties of Pumpkin Seed (*Cucurbitaceae spp*)

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**Abstract:** The study investigated the effects of moisture content and varietal factors on some physical properties of pumpkin seed at three levels of moisture content (18.1, 22.2, and 26% d.b) and two levels of variety (*c. maxima* and *c. pepo*). A 2X3 factorial experiment in a Randomized Complete Block Design (RCBD) was used, and results were analyzed with the analysis of variance (ANOVA) using the General Linear Model procedure of the SPSS 17 at 5% level of probability. The major, intermediate and minor dimensions increased linearly from 13.1 to 14.3mm, 8.76 to 9.24mm, and from 2.64 to 3.04mm respectively in *c. maxima* variety respectively. Correspondingly, these dimensions increased from 17.9 to 18.3mm, 11.2 to 11.7mm and from 4.53 to 4.78mm respectively in *c. pepo* variety between 18.1 to 26% d.b. The surface and projected areas of pumpkin seed at 18.1% d.b were 141 and 89.9mm<sup>2</sup> in *c. maxima*, and 292.8 and 157 mm<sup>2</sup> in *c. pepo*. Bulk and true densities of 0.397 and 1.53g/cm<sup>3</sup> were recorded at 18.1% d.b in *c. maxima*, and 0.335 and 1.53g/cm<sup>3</sup> respectively in *c. pepo*.

**Keywords:** Moisture content, variety, variation, *c. pepo*, *c. maxima*

### I. Introduction

Pumpkin a fruity vegetable belonging to the family of cucurbitaceous has been cultivated for a wide range of a purposes ranging from nutritional to medicinal applications [1]; pumpkin seed contain moderate concentrations of minerals especially magnesium and potassium [2], and as such pumpkin seed was effectively used in the formulation of drugs which were significant against worms, high blood pressure, diabetics, and in enhancing immune response in human beings [3]. The world production of pumpkins, squashes, and gourd is estimated up to 17.7million metric tons per annum [4]; however pumpkin seeds have not been utilized commercially in this region of the world. To design equipment for aeration and storage of pumpkin seed, there is the need to know the various physical properties as a function of moisture content [5]. Similarly the physical properties of agricultural materials are necessary in the optimization of facilities and processes such as harvesting, handling, and storing etc. The design of separation, sizing, harvesting, handling and planting machines require the knowledge of the size and shapes of agricultural materials, [6]. Similarly, surface and projected area are necessary for the design of pneumatic separation machines, in the estimation of wrapping materials such as foils, wax etc. and in calculating the rate of heating, freezing and drying processes [7]. While seed volume is important in the design of seed plates and metering mechanisms of planters, moreover, the knowledge of seed volume at varying moisture content gives an indication of when it is most suitable to handle agricultural materials at cheaper cost. Seed porosity, particle and bulk density are necessary for the design of storage structure, grain hopper and as indicators of kernel filling during growth; seed with low porosity is likely to have greater resistance to fluid flow/escape during drying process, thus higher power is required to drive aeration fans [8]. The objectives of this study was to investigate some moisture dependent properties of pumpkin seed namely axial dimensions, sphericity, surface and projected area, seed volume and porosity, kernel and bulk density in the moisture content range between 18.1 and 26.0% d.b

### II. Materials and Methods

Dry pumpkin seeds were obtained from a local market in Mayo-Nguli, Maiha local government area of Adamawa state (located between latitude 10°.02<sup>1</sup>N and 10°.15<sup>1</sup>N and longitude 13°.09<sup>1</sup>E and 13°.16<sup>1</sup>E). The post harvest moisture content of 14.47% d.b and 12.13% db for the *c. maxima* and *c. pepo* varieties respectively were determined by oven drying method in accordance with the procedures of [9] and computed using (1)

$$MC_{db} = \frac{(m_2 - m_1) - (m_3 - m_4)}{m_3 - m_1} \quad \dots (1)$$

Where

$m_1$  = mass of empty moisture can (g),  $m_2$  = mass of air-dried sample + moisture can (g)

$m_3$  = mass of oven dried sample + moisture can (g)

The desired moisture content of 18.1, 22.2 and 26.0% d.b were obtained by conditioning pumpkin seed (i.e. rewetting); this involved adding calculated quantity of distil water. The rewetting procedure adopted was

equally employed by researchers in investigating the moisture dependent properties such as pistachio nut, cucurbit, bean, shea nut, and cotton seeds [14], [10], [11], [12], and [13] respectively.

$$Q = \frac{W_i(m_f - m_i)}{(100 - m_f)} \quad \dots (2)$$

$Q$  = The quantity of distil water needed to obtain the desired moisture content during the rewetting process.

$W_i$  = Weight of pumpkin seed before rewetting (g),  $m_f$  = final moisture content of pumpkin seed (% d.b),  $m_i$  = Initial moisture content of pumpkin seed (% d.b)

The rewetted pumpkin seed were packed in a low density polyethylene bags and stored in a refrigerator at 5°C for 72 hours [12]; this was done to create a favourable environment for the absorption of moisture by pumpkin seed and to prevent the action of microbes on the wet pumpkin seed. The major, intermediate, and minor dimensions of pumpkin seed were measured using a digital Vanier caliper of resolution 0.01mm. At each moisture content level, one hundred pumpkin seed were used, (i.e. twenty five seeds were measured and replicated four times). The means and standard deviation of these measurements were calculated and reported. The sphericity and aspect ratio were calculated in terms of the axial dimensions of pumpkin seed using equations (3) and (4) respectively, [11].

$$\phi = \frac{(LWT)^{0.33}}{L} \quad \dots (3)$$

$$R_a = \frac{W}{L} \quad \dots (4)$$

Where:  $\phi$  = Seed sphericity,  $R_a$  = Aspect ratio, L= Major dimension, W= Intermediate dimension, T= Thickness  
The projected and surface areas of pumpkin seed were calculated using equations (5) and (6) respectively, [15].

$$A_p = \left(\frac{\pi}{4}\right) * L * W \quad \dots (5)$$

$$A_s = \pi D_g^2 \quad \dots (6)$$

Where:  $A_p$  and  $A_s$  are the projected and surface areas (mm<sup>2</sup>),  $D_g$  = geometric mean diameter (mm).

The bulk density was determined using a 500ml measuring cylinder, digital weighing balance of resolution 0.1g (YP 10KN Hundhill Ltd England). The measuring cylinder was filled with pumpkin seed at certain moisture content, the excess seeds were removed by sliding a wooden rule along the edges of the cylinder and the combined mass of the seed and the cylinder was obtained. Bulk density was calculated using equation (7) in accordance with [16].

$$\rho_b = \frac{(g_2 - g_1)}{V} \quad \dots (7)$$

$\rho_b$  = bulk density (g/cm<sup>3</sup>),  $g_2$  = weight of cylinder + pumpkin seed (g),  $g_1$  = weight of empty cylinder (g), V = Inner volume of cylinder (cm<sup>3</sup>)

To determine the kernel density of pumpkin seed, 15ml measuring cylinder, ureca can, toluene fluid (Sigma-Aldrich, Germany) and a digital weighing balance were used. The kernel density was determined using Archimedes' principle in accordance with [6], and was calculated using equation (8).

$$\rho_t = \frac{m_s}{v_s} \quad \dots (8)$$

Where:  $m_s$  = mass of seed (g),  $v_s$  = true volume of seed (cm<sup>3</sup>),  $\rho_t$  = true/ kernel density (g/cm<sup>3</sup>)

### III. Results and Discussions

#### A. Results:

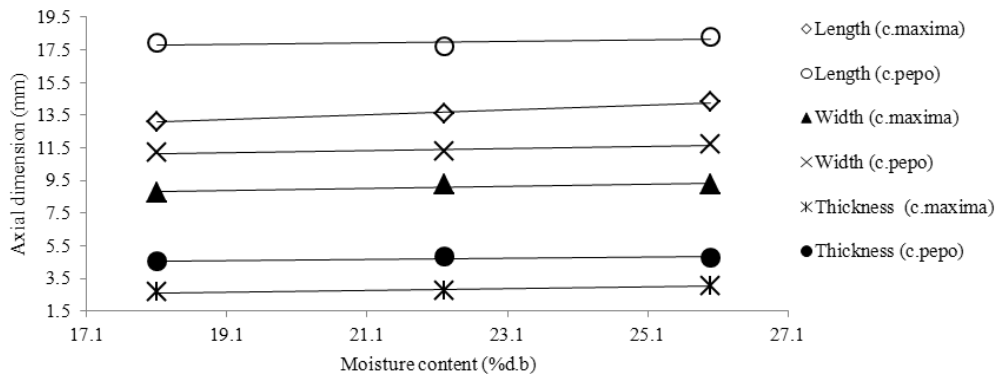


Figure 1. Axial dimensions of pumpkin seed at varying moisture content

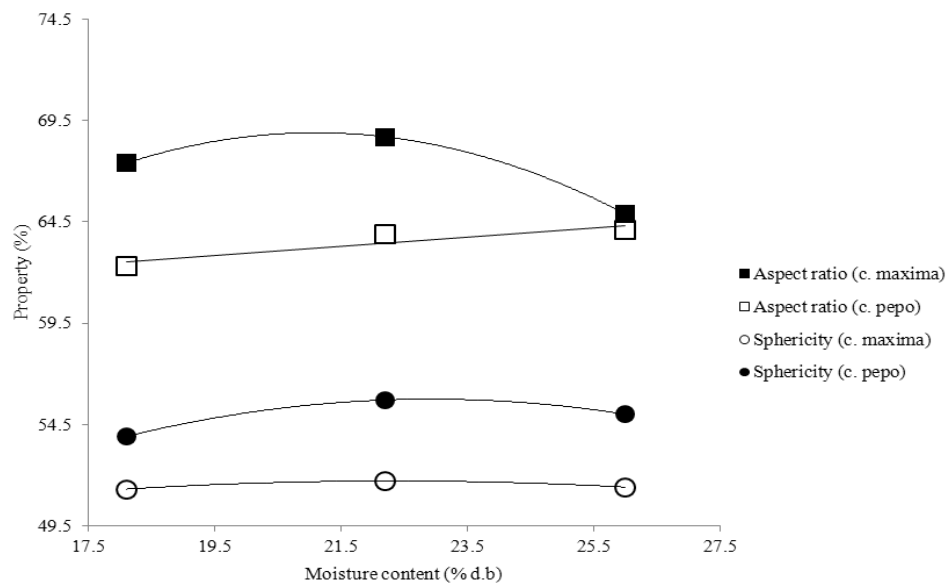


Figure 2. Porosity, sphericity and aspect ratio of pumpkin seed at varying moisture content

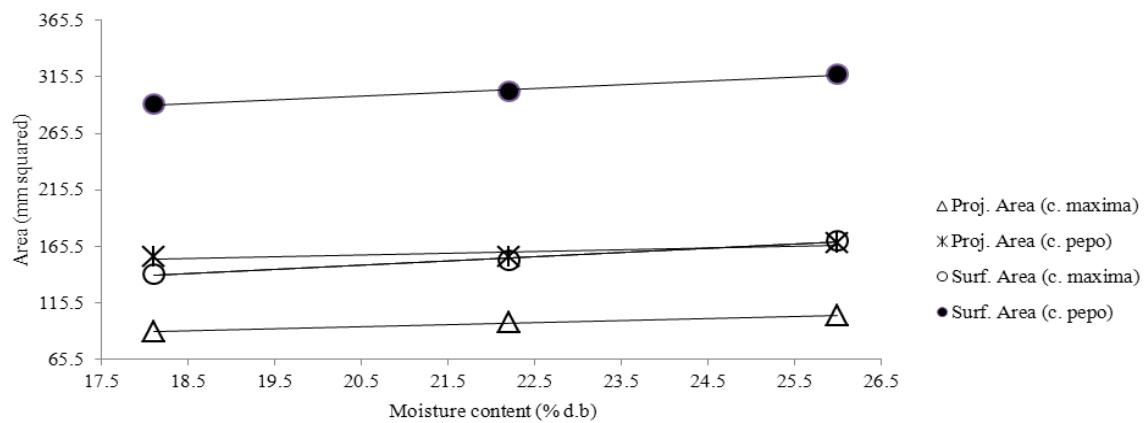


Figure 3 . Surface and Projected Areas of pumpkin seed at varying moisture content

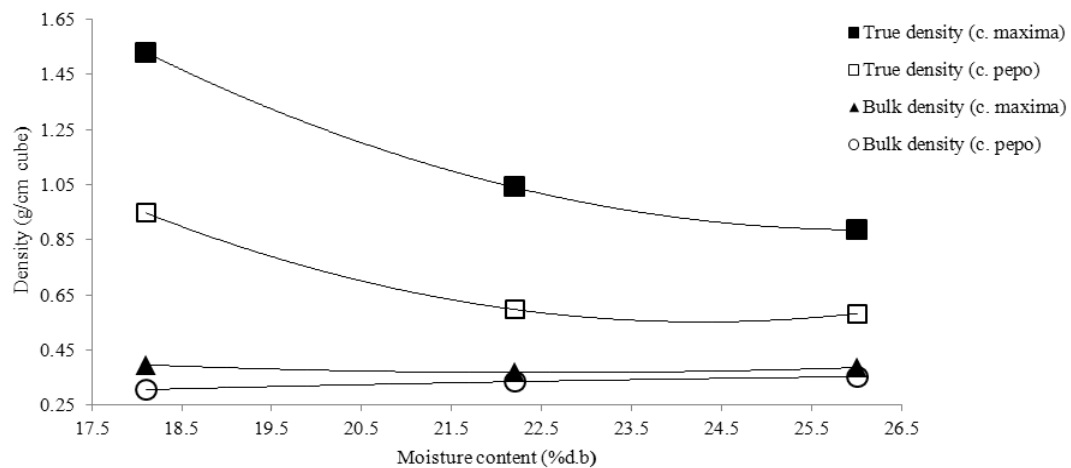


Figure 4. Bulk and true densities of pumpkin seed at varying moisture content

**Table 1 Analysis of variance (Mean Squares) for the major, intermediate, minor dimensions, aspect ratio and sphericity of pumpkin seed**

Mean squares (MS)						
Sources of variation	DF	Axial dimension (mm)			Dimensional ratio	
		Major	Intermediate	Minor	Sphericity	Aspect ratio
Replication	3	1.12 <sup>ns</sup>	0.383*	0.0183 <sup>ns</sup>	0.51 <sup>ns</sup>	46.4*
Treatment	5	23.2*	6.57*	4.40*	36.6*	49.7*
Variety (Var)	1	112*	31.5*	21.5*	35.0*	80.7*
Moisture content	3	0.645 <sup>ns</sup>	0.503*	0.208 <sup>ns</sup>	2.55*	7.88 <sup>ns</sup>
MC*Var	2	57.5*	0.153 <sup>ns</sup>	0.064 <sup>ns</sup>	54.0 <sup>ns</sup>	76.0*
Error	15	0.503	0.0493	0.124	4.49	8.05

\* Significant at 0.05% level, ns not significant

**Table 2 Analysis of variance (Mean Squares) for the surface, and projected areas, bulk and true densities of pumpkin seed**

Sources of variation	DF	Surface area	Projected area	Bulk density	True density
Replication	3	1836.8 <sup>ns</sup>	119.9*	0.000523 <sup>ns</sup>	0.09 <sup>ns</sup>
Treatment	5	24808.1*	4889.2*	0.0269*	0.462*
Variety (Var)	1	112.3 <sup>ns</sup>	23688.1*	0.0092 <sup>ns</sup>	1.24*
Moisture content	3	4387.5*	319.53*	0.000375 <sup>ns</sup>	0.442*
MC*Var	2	57.6 <sup>ns</sup>	61.3*	0.062*	0.095*
Error	15	826.2	10.98	0.00651	0.0122

\* Significant at 0.05% level, ns not significant

**B. Discussions:**

The result of the variations of axial dimensions with moisture content is displayed in figure (1). The figure indicated that all the axial dimensions increased linearly with moisture content between 18.1 and 26.0% d.b; the major, intermediate and minor dimensions increased from 13.1, 8.76, and 2.64mm to 14.3, 9.24, and 3.04mm respectively. Correspondingly, in *c. pepo* variety these dimensions increased from 17.9, 11.2 and 4.53mm to 18.3, 11.7, and 4.78mm respectively. The mean values and the trend of variation of axial dimensions with moisture content in *c. maxima* variety was consistent with findings for cucurbit, and sunflower seeds, [11], [15]. The axial dimensions in this study were smaller than the dimensions of African oil bean seed, [7], but larger in comparison to the dimensions of soybean, and cowpea seeds at comparable moisture content [10], and [11]. However, reference [17] reported a decreasing effect of moisture content on the major dimension of millet seed between 13 to 15% d.b. The effects of moisture content was significant only on the intermediate dimension ( $p < 0.05$ ), whereas variety factor was significant on all axial dimensions of pumpkin seed (Table, 1).

The results of the variations of dimensional ratios of pumpkin seed with moisture content is displayed in figure (2). The figure indicated that the aspect ratio in both varieties was higher than the corresponding seed sphericity at each moisture content level and varieties investigated. Aspect ratio in *c. maxima* increased polynomially from 67.4% to 68.7% between 18.1 and 22.2% d.b, this later decreased to 64.9% upon increase in moisture content to 26% d.b. Equally, seed sphericity of *c. pepo* indicated a polynomial increase from 53.9% to 55% between 18.1 and 26.0% d.b. Whereas, seed sphericity and aspect ratio in *c. maxima* and *c. pepo* respectively had linear relationships with moisture content between 18.1 and 26.0% d.b. This trend was earlier reported for African oil bean seed, cottonseed, and walnut, [7], [14], [20], and [17]. However, a decrease in seed sphericity with increase in moisture content was reported for Ex-Borno variety of millet [17]. The effects of moisture content and variety factors on seed sphericity were significant ( $p < 0.05$ ), nevertheless only variety factor was significant on aspect ratio ( $p < 0.05$ ), (Table, 1); this suggests that sieving or separating machine with circular holes will not easily let pumpkin seeds through its holes, similarly during material handling, seed rolling is less likely to occur. The seed sphericity of pumpkin seed in this study is lower than that of *lablab purpureus* [18], and cottonseed [14].

The result of the variations of surface and projected areas of pumpkin seed with moisture content are presented in figure (3). The figure shows that moisture content had an increasing linear effect on the areas of pumpkin seed between 18.1 and 26.0% d.b; surface area increased from 141 to 206mm<sup>2</sup> and from 292 to 318mm<sup>2</sup> in *c. maxima* and *c. pepo* varieties respectively. These values were higher than the surface area reported for cowpea and fenugreek seeds [12] and [5]; nevertheless, it was lower in comparison to the surface area of tigernut, and chiny variety of cucurbit seed, [19] and [11]. The effect of moisture content was significant on the surface area of pumpkin seed ( $p < 0.05$ ) (Table, 1), unlike the variety factor which was not. This suggests that it is advisable to store pumpkin seed at lower moisture content; since lower surface area means less area for moisture absorption during storage, [19]. Correspondingly, the projected area increased from 89.8 to 130mm<sup>2</sup> and from 157 to 168mm<sup>2</sup> in *c. maxima* and *c. pepo* varieties respectively. Reference [20] reported similar trend between moisture content and projected area for shelled walnut (45.8 to 47.74cm<sup>2</sup>) and kernel walnut (27.2 to 29.9 cm<sup>2</sup>) in the moisture content range between 11.5 and 23.3%db and between 4.93 and 32.3% d.b respectively.

The results of the variations of bulk and true density of pumpkin seed with moisture content is presented in figure (4). The figure illustrates that moisture content had linear decreasing effect on both varieties, whereas

polynomial relationship was observed between bulk density and moisture content in both varieties in the moisture content range between 18.1 and 26.0% d.b. True density decreased from 1.53 to 0.868g/cm<sup>3</sup> and from 0.834 to 0.607g/cm<sup>3</sup> in c. maxima and c. pepo varieties respectively. This suggests that at higher moisture content, the suitability of using water as a medium of conveyance increases. Similar findings were reported for rape seed, black grape, and fenugreek, cowpea seed, cottonseed [21], [22], [5], [12], and [14] respectively. Nevertheless, an increase in true density with moisture content was reported for sunflower seed, barley grains, lablab purpureus, Ex-Borno variety of millet, and walnut, [15], [14], [18], [17], and [20] respectively. The range of the true density in this study (0.607- 1.53g/cm<sup>3</sup>) was within the range of true density values reported for barley, and cottonseed, [14], but lower in comparison to the true density of lablab purpureus, soybeans, and higher when compared with the true density of walnut. Despite the fact, the bulk density of pumpkin seed decreased from 0.397 to 0.368g/cm<sup>3</sup> with the initial increase in the moisture content, further increase in moisture content resulted in the slight increase in bulk density to 0.387g/cm<sup>3</sup> in c. maxima variety. Similarly, in c. pepo variety it decreased from 0.335 to 0.306g/cm<sup>3</sup> before increasing to 0.356g/cm<sup>3</sup> as the moisture content was increased from 18.1 to 22.2 and to 26.0% d.b subsequently. By implication, pumpkin seed is likely to have higher terminal velocity thereby increasing the tendency of separating lighter materials from pumpkin seed during pneumatic separation, [20].

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